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# Soviet Human Factors

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**Scientific and Technical Intelligence Committee**

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*STIC 85-003*
*April 1985*

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**Preface**

This assessment was prepared by the Scienctific and Technical Intelligence Committee's Life Sciences Working Group. It examines the Soviet human factors (HF) R&D effort, particularly as it applies to Soviet military capabilities. The study addresses Soviet human engineering efforts to better design the machine element of man-machine systems and Soviet research to optimize human performance through selection and performance enhancement techniques. Comparisons between US and Soviet HF R&D programs are made.

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# Soviet Human Factors [redacted] 25X1

## Key Judgments

Human engineering, a subject largely neglected by the Soviets until the 1960s, now has a substantial influence on the design of military systems. Soviet military systems currently in development probably are receiving human engineering input and evaluations comparable in scope to those applied to US systems. Future Soviet systems should be relatively well designed in terms of man-machine integration and will utilize available operator-support technologies such as voice input-output and advanced information displays. [redacted] 25X1

The Soviets have an extensive program to improve pilot performance, flight safety, and reliability through workload reduction. Soviet human factors engineering has decreased pilot workload by 20 to 40 percent since the late 1950s with the use of grouped displays, color-coded displays, standardized displays and instruments, and new types of displays. Dial displays are color coded to indicate regions of acceptable, marginal, and unsafe conditions. [redacted] 25X1

Soviet human engineers are probably heavily involved in determining the degree of simulator fidelity required to obtain optimal levels of pilot training and are probably also involved in prioritizing fidelity requirements in design trade-offs, because cost or technological considerations often make the optimum impractical. Flight simulators are heavily used by the Soviet military, and Soviet pilots log almost as much simulator time as flight time. Consequently, the fidelity of simulators contributes substantially to pilot proficiency and net system performance. [redacted] 25X1

In general, the Soviets credit their better operator selection programs with halving training washout rates, reducing operator-related accidents by 30 to 40 percent, and increasing the effectiveness of military systems by 10 to 15 percent. Soviet selection research is becoming more mission oriented in its goals. For example, attempts are being made to identify pilot candidates with unusually stable vestibular resistance to optokinetic stimuli for assignments involving frequent low-altitude flights and to create distinct selection criteria for tank commanders, drivers, and gunners. [redacted] 25X1

A dominant goal of Soviet human factors researchers, pursued with an emphasis unmatched elsewhere, is the creation of man-machine systems in which performance-related psychophysiological operator states are continuously assessed and characteristics of the man-machine interface are automatically altered to reflect the operator's current capabilities. [redacted] 25X1

[redacted] 25X1

[redacted] This emphasis springs from significant operator errors observed in military exercises and the Soviet perception that these problems would be greatly magnified in wartime, severely reducing operational effectiveness. The behavioral modification techniques most likely to enhance the effectiveness of Soviet military man-machine systems are biofeedback and drug therapy. [redacted] 25X1

As the biochemical bases of human performance become increasingly well understood, the Soviets will attempt to apply pharmacological research results to additional military performance problems. Key goals probably are the enhancement of operator memory (particularly short term), increased hypoxia resistance, and rapid correction of circadian disturbances. [redacted] 25X1

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# Contents

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# Soviet Human Factors [redacted] 25X1

## Introduction

Human factors are those considerations in man-machine systems that influence the operator's or crew's ability to use their equipment effectively and that, thus, determine net system performance. Both military experience and research have demonstrated that under battle conditions significant and often extreme reductions in man-machine performance occur in comparison with the same systems tested under ideal peacetime conditions (no operator or crew fatigue, negative emotional states, excessive physical stresses, and selection or training inadequacies). The estimated performance decrement varies among systems and in accordance with methodologies employed to estimate the decrement; the US Army estimates, for example, that, under wartime conditions, the average M-60 tank crew achieves [redacted] of theoretical peacetime system performance. Human factors R&D is an attempt to minimize the departure from ideal performance in man-machine systems and thus to provide a significant force-multiplying effect. Estimates of the effectiveness of Soviet weapon systems, which neglect the consideration of human factors qualities, are inherently vulnerable to significant error. The potential for substantial near-term improvements in Soviet battlefield effectiveness exists, since the Soviet Ministry of Defense (MOP) has, within the past decade, radically upgraded the importance of human engineering as a system design priority. [redacted]

An almost limitless number of machine designs would be possible if equipment designers were merely constrained by their imaginations and available material technologies. In reality, consideration must be made in system design for the human operator, since all systems are at some point controlled by humans. The designer's choices are limited by man's mental and physical abilities under the anticipated operational conditions. In the United States, intuitively based inclusion of operator requirements in system design was first recognized as insufficient during World War II, when it became apparent that it was possible to construct weapons that, in critical situations, could not be controlled by humans. As an initial corrective measure, psychologists attempted to select those persons best able to cope with wartime missions and machines, making operator selection the earliest human factor to receive concerted attention. Technological advances and evolving mission requirements have enlarged the array of human factors problems that can beset military operators. Multigravity accelerations, continuous operations, extreme environments, and the psychological stress associated with the lethality of modern weapons are a few of these problems. Numerous scientific disciplines and technological approaches have been called upon to optimize the design of equipment, making human factors research a multidimensional effort. The discipline is dominated in the United States by psychologists, particularly engineering psychologists. [redacted] 25X1

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Human factors research was begun in the Soviet Union in the late 1950s by physiologists and by psychologists strongly inclined toward physiological methods. Consequently, Soviet human factors research is traditionally biased toward the human element of man-machine systems. They are chiefly concerned with methods by which human capabilities can be quantified and enhanced independent of appropriate system design, that is, they tend to select or modify the man to fit the machine. Designing equipment to be consistent with human capabilities—human engineering—has been less explored in the USSR. The ratio of effort between the two is about 2:1. This imbalance is probably changing rapidly because engineering psychology and improved human engineering of equipment are being strongly emphasized by Soviet academic and military establishments. [redacted] 25X1

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## Human Engineering

One of Stalin's legacies is the relatively poor human engineering of most fielded Soviet military equipment and systems. A major cause of these deficiencies is traceable to Stalin's repression of the behavioral

sciences on grounds of ideological incompatibility; applied psychology, with its penchant for aptitude and personnel selection tests, was provocatively nonegalitarian, and the area was little pursued until Stalin's death. It was only in 1959 that the first Soviet engineering psychology laboratory was established (at Leningrad University under Boris F. Lomov). In the United States, research on human engineering problems was begun in the 1940s. The first Russian book on engineering psychology did not appear until 1963, and, of necessity, it borrowed heavily from Western texts. It is not surprising that only equipment fielded in recent years provides evidence that human engineering has become a significant Soviet design consideration, given the long development cycles of weapon systems and a relative dearth of human engineering specialists until at least the mid-1960s.

**Civilian Resources**

Although the establishment and growth of several civilian Soviet human engineering facilities has been nominally justified by academic and industrial needs, defense requirements probably were the primary impetus for their creation. Military contracts continue to be a prime source of funds. As Boris Lomov has stated, "The military takes the most advanced aspects of new technologies." Following Lomov's establishment of an engineering psychology laboratory at Leningrad University, other laboratories soon opened at Moscow State University, Khar'kov University, and the Institute of Psychology and Pedagogy. About 1965, a human engineering laboratory was established within the Scientific Research Institute of Automatic Apparatus in Moscow, a lead organization in systems engineering specializing in computer systems. By the mid-1960s, the world's largest human engineering facility had been created, the USSR Research Institute for Industrial Design (VNIITE). VNIITE is charged with developing state standards governing the ergonomic design of civilian products (50 to 80 such standards are planned). The institute employs 500 persons at its Moscow headquarters and about 1,500 more at the nine branches listed below with their identified areas of expertise:

- Vilnius—anthropometrics, machine tools.
- Leningrad—display systems, machine tools.
- Yerevan—automobiles, tractors.
- Tbilisi—visual communications, social psychology.
- Khar'kov—automated processes, operator stations.
- Kiev—control systems, control panels, environmental stresses.
- Khabarovsk—ships.
- Sverdlovsk—railroad equipment, physiological and hygenic factors.
- Minsk—tractors, farm equipment, dump trucks, miniaturization. 25X1

As the central clearinghouse for human engineering R&D, VNIITE maintains relationships with approximately 1,000 other design institutes in the USSR. In addition, VNIITE oversees and coordinates all East European ergonomic research. In this connection, specific assignments for the development of human engineering standards have been given to the various Bloc countries. East Germany is responsible for developing both psychological criteria and methods of assessing ergonomic quality of industrial articles. 25X1 Romania is developing principles for optimizing labor and systems, and Czechoslovakia is concerned with optimizing motor activity of operators. The Czechoslovaks and Bulgarians are jointly working on ergonomic requirements for information displays, and Poland is responsible for developing static and dynamic anthropometric data. Anthropometric atlases for the populations of Bulgaria, Poland, and the USSR have been compiled. These standards will have universal application in the Bloc countries 25X1

In 1970, Boris Lomov edited the book, *Military Human Factors Engineering,* the first of its kind in the Soviet Union. His argument for proper human engineering in advanced military systems seems to have been rewarded in 1971 when the Institute of Psychology of the USSR Academy of Sciences, was created with Lomov as director. The institute, which is charged with coordinating all psychological research in the Soviet Union, heavily emphasizes engineering psychology and is largely dependent on MOP contracts. The institute, believed to employ 800 personnel, is able to draw upon the brightest psychologists in the USSR and to influence Soviet psychology heavily toward applied research problems—approximately 25 percent of Soviet psychologists are engineering psychologists versus 0.5 percent in the United

States. The Soviet academic base in human engineering will be further increased if a 1981 recommendation by the Academy of Sciences that human engineering departments be established at all higher engineering schools is implemented. This recommendation, demonstrating the degree of official recognition the field has attained, was part of a special decree by the Presidium of the Academy of Sciences emphasizing the urgent need for increased Soviet human engineering research. [redacted]

**Military Resources**

It is clear that, during the 1970s, the MOP relied heavily on the civilian academic and industrial human engineering establishment for basic and applied research on military human engineering problems. For example, Lomov has described the Institute of Psychology's work in the redesign of an ineffective heads-up display (HUD). The original HUD was so poorly designed that the device actually degraded pilot performance in low-level flight by overburdening the pilot with nonessential information. According to Lomov, when the HUD was redesigned in accordance with human perceptual and short-term memory capabilities, gains of 25 percent in piloting accuracy and 30 percent in ground observation time and a tenfold reduction in pilot reaction time to emergency signals were attained. Less is known, however, of the structure of the military's human engineering establishment. Human engineering laboratories are known to exist at various Soviet naval, air force, and army academies [redacted] Servicewide human engineering centers comparable to the US Army's Human Engineering Laboratory probably exist, but only that of the Strategic Rocket Forces (established in 1980) has been identified. Published research, however, indicates that more Soviet officers (particularly field-grade officers) are involved with human engineering problems than are US military officers and that a substantial military human engineering bureaucracy exists. [redacted]

**Military Design Priorities**

The stage of the equipment development cycle at which human engineering is done is highly important to its impact on weapon system effectiveness. Ideally, the integration of man and machine begins at the conceptual stage of system design; in the worst case, human engineering is called upon to remedy system design defects found to degrade operator performance significantly in fielded equipment. Such retroactive human engineering is usually limited in scope and highly expensive if it requires basic design changes. The Warsaw Pact countries are currently retrofitting, at significant cost, T-55 and T-62 tanks with power-assisted steering and clutches, partly to improve driver performance. They also are making other modifications to facilitate drive performance and, consequently, tank mobility. Soviet human engineers, like their US counterparts, have continually sought an earlier and more influential voice in the equipment development process. The following points indicate they have at least partially succeeded for key Soviet military systems: 25X1

- [redacted] in the mid-1970s, a high-level MOP decision was made to require human engineering evaluation and approval of all new major items of equipment prior to production. 25X1

- "Cockpit commissions," which include engineering psychologists [redacted] analyze cockpit mockups in terms of pilot interactions and workload for military aircraft still in the conceptual design stage. 25X1

- Strong evidence exists that human engineering is now considered during the initial design stages for tanks. [redacted] 25X1

The apparent elevation of human engineering from virtual nonconsideration as a design priority in the 1950s to an early and significant design consideration by the 1980s should substantially improve the combat effectiveness of future Soviet military equipment. 25X1

[redacted] 25X1 the Soviets have recognized that critical human engineering deficiencies in fielded equipment have hindered their competiveness with Western armaments, as consistently demonstrated in Middle East conflicts. [redacted] 25X1 25X1

 

Human engineering has the potential to radically influence design philosophies; however, the solutions it may propose are largely unknown. For example, human engineering considerations could convince the Soviets to increase the crewspace in tanks, resulting in future Soviet armor more similar to Western tanks in terms of height and endurance. Alternatively, advanced human engineering research could investigate the feasibility of further automating tanks and reducing crews from three to two men. Such diverse prospects require the Intelligence Community to develop an improved understanding of Soviet military human engineering research if projections of future combat equipment and effectiveness are to be valid. [redacted]

**Aircraft Human Engineering**

Both in the United States and the USSR, aerospace man-machine problems were among the earliest to generate concerted human engineering attention. A synopsis of Soviet aircraft human engineering illustrates the types of problems addressed by Soviet military human engineers. [redacted]

Soviet aerospace human factors and ergonomics are concerned with optimizing pilot-aircraft interaction to improve flight safety, performance, and reliability. Those improvements are achieved through design criteria that consider the location, arrangement, and legibility of controls and displays; ease of operating controls; and pilot comfort. Considerable success has been realized to date by Soviet human factors engineers in display design, instrument layout, workload reduction, performance improvement, and overall "operational readiness" of airborne weapon systems. The late aircraft designer, Oleg K. Antonov, credited Soviet human factors engineers with decreasing pilot workload by 20 to 40 percent since the late 1950s. A good indication of how Soviet aerospace human factors have improved is provided by a comparative analysis of the ergonomic design features of recent Soviet aircraft cockpits with older, analogous aircraft. [redacted]

An early and major emphasis of Soviet aerospace ergonomics was display design. In recent years, designers have incorporated grouped displays, color-coded displays, standardized displays, and new types of displays into Soviet aircraft to reduce information processing time and workload. [redacted]

With regard to grouped displays, an improvement in the placement of indicator lights is evident in modern Soviet aircraft over older models. In the MIG-17, for instance, indicator lights are scattered across the entire forward instrument panel, while those on the MIG-23 (figure 1) and MIG-25 are grouped by functions. Such grouping aids the pilot in monitoring and rapidly checking aircraft systems. The MIG-25's indicator lights are arranged in two main groups with an additional "master" warning light centrally located on the instrument panel. When lit, the master warning light cues the pilot to check individual indicator lights for the specific malfunction. [redacted]





Another aspect of display design involves color coding. Compared with older Soviet aircraft, the MIG-25 makes extensive use of color on display instruments. Dial displays are color coded to indicate regions of acceptable, marginal, and unsafe conditions with green, yellow, and red scale colorations, as in many Western aircraft. The IL-76 transport also uses generous color coding for instrument pointers, markers, scales, and regions of safe operation. Color coding facilitates quick cross-checking of cockpit instrument readings, helps differentiate between instruments and controls, and enhances the clarity of displayed information. [redacted]





In addition, Soviet human engineers have stressed the importance of standardizing basic flight instruments. A case in point involves the gyro horizon. Two different methods exist for displaying angle-of-bank information to the pilot; both methods incorporate a representation of an aircraft and a horizon line. In the standard Western convention, the horizon line moves, and the aircraft symbol centered on the dial does not (an "inside-out" design). The reverse method, which utilizes a fixed horizon and a movable aircraft symbol (an "outside-in" design), is found on all modern Soviet aircraft. Figure 1 shows an outside-in gyro horizon on the MIG-23. Soviet human engineers consider this to be the preferable convention in terms of facilitating the pilot's correct mental image of his flight situation, a belief which has received support in Western laboratory studies. [redacted]

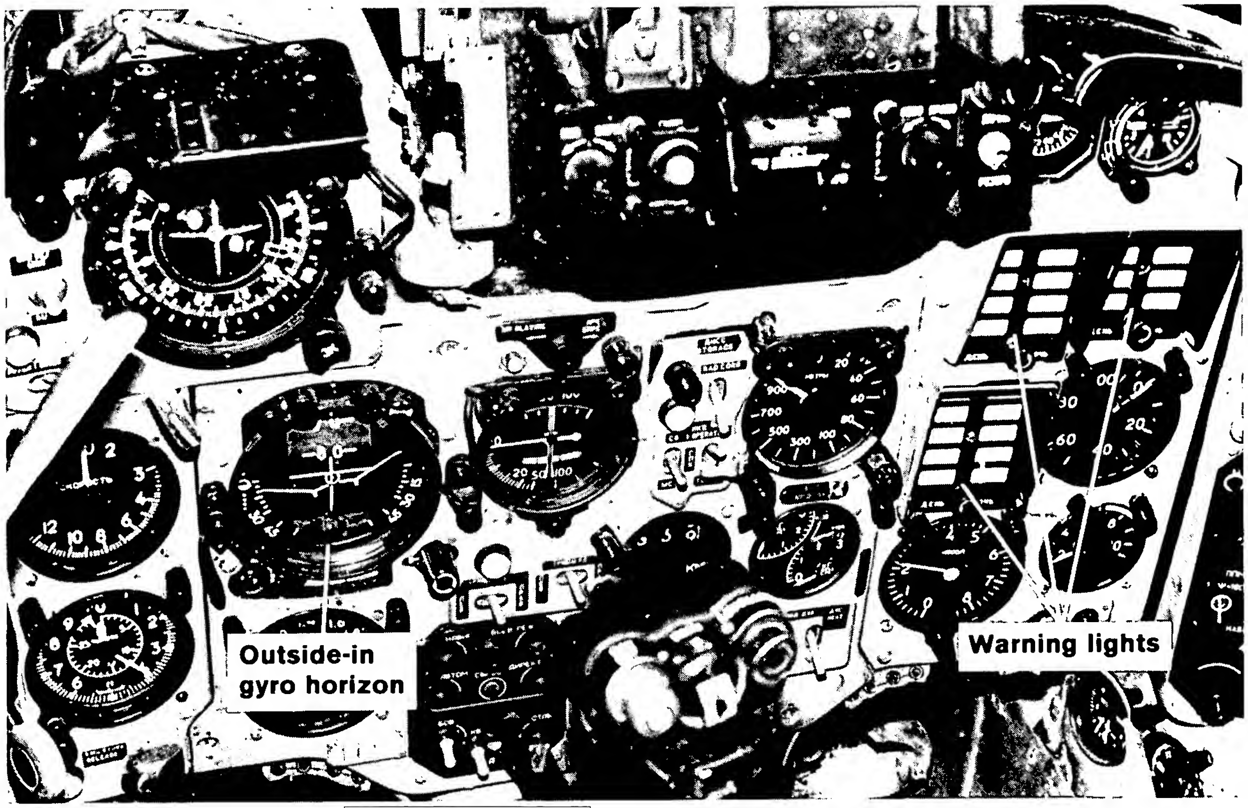


*Figure 1. MIG-23 Instrument Panel* 25X1

Standardization of optimum designs, however, is evidently a problem for Soviet human engineers, who have expressed chagrin that both types of gyro horizons remain in the Soviet inventory and that cases are known of single aircraft having both types. Human factors engineers are also trying to standardize color conventions in gyros. The usual practice (blue "sky" and black or brown "ground") is reversed on some fighter gyro horizons. Soviet human factors engineers are trying to eliminate such discrepancies to reduce pilot error and facilitate pilot retraining on new aircraft.

Soviet aircraft designers have incorporated several new types of displays in aircraft cockpits. The IL-76 and IL-86 are equipped with vertical strip indicators (figure 2), which greatly reduce reading time for information such as altitude and engine parameters. The HUD has been in use for over a decade on the Flogger weapon system and has been improved with successive models. It displays target, sight, and target data such as range and closure rate on a combining glass in front of the windscreen, enabling the pilot to maintain close visual contact with a target. The newest Soviet HUD, used on the MIG-29 and SU-27, is fairly sophisticated and is probably capable of displaying aircraft performance, flight commands, and attack commands, as well as target data. An auditory display—a voice warning system—has been in use for a decade on the MIG-25 and is probably used on subsequent fighters. The warning system uses a recorded female voice and advises the pilot of 16 unsafe conditions. 25X1

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Human engineers have improved Soviet cockpits with the proper coding and labeling of controls. For instance, older aircraft, such as the MIG-17, do not have a shape-coded landing gear lever (a common

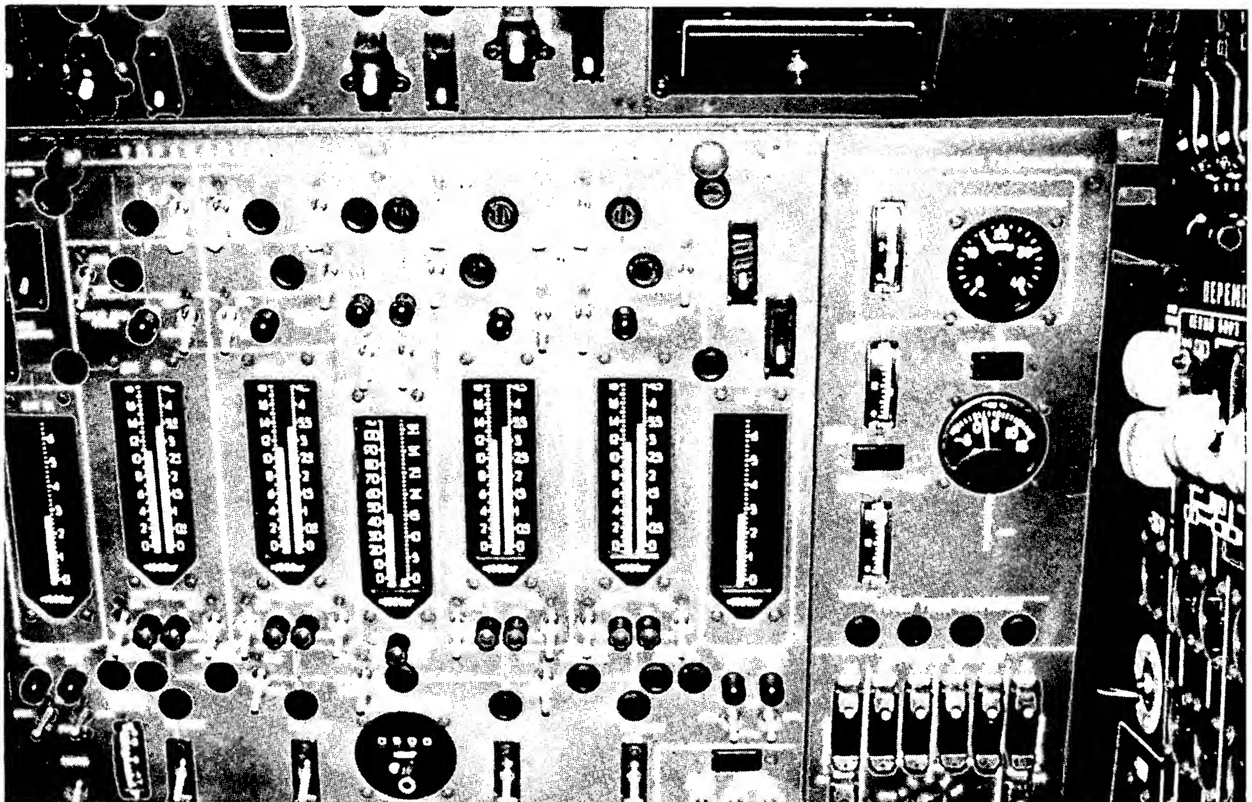

*Figure 2. Vertical Scale Displays*

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Western practice). More recent aircraft, such as the MIG-21, MIG-23, and MIG-25, have this feature. The MIG-17 also does not incorporate much color coding of controls other than emergency controls, whereas the MIG-25 makes liberal use of color-coded controls. Labeling inconsistency is found on the early model MIG-21—some switch labels are positioned above the switches and some below. In a bank of similar switches, this inconsistency causes confusion and increased error rates.

A control enigma on the MIG-17 and early model MIG-21 involves the armament selector switch, apparently mislocated on the right-hand instrument panel. The pilot must release the control stick to switch from missiles to guns (or vice versa), a considerable hindrance during air-to-air combat. The Soviets corrected this problem on late model MIG-21s by placing the missile launch switch near the gun trigger on the control stick. Designers, however, moved the armament selector switch to the lower center instrument panel between the pilot's legs on the Flogger B and Flogger G. This move permits operation with the left hand, eliminating control stick interference, but now the pilot must use his left hand to operate the armament selector switch while controlling both the throttle and the wing sweep lever. Although this placement seems to indicate inadequate consideration of human factors design principles, it may simply represent design trade-offs with other considerations.

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The latest Soviet automatic control system, the SAU-155 on the MIG-25 and MIG-31, receives inputs from the controls, data links, navigation systems, instruments, and the central digital computer. It can provide completely automatic flight, autonomous or ground controlled, except for takeoffs and landings. Should the pilot become disoriented or lose control of

the aircraft, he can depress a special "leveling" button on the control stick which commands the SAU-155 to bring the aircraft automatically to a straight and level attitude. This emphasis on automatic control reiterates the importance that the Soviets place on human engineering objectives, such as workload reduction to improve pilot performance.

Flight simulators are heavily used by the Soviet military. Pilots, by regulation, must spend 30 minutes simulating a mission in exact detail before actually flying it. Since Soviet fighter sorties usually last only 30 to 40 minutes, Soviet pilots log almost as much simulator time as flight time (100 versus 120 hours per year). Consequently, the fidelity of simulators contributes substantially to the quality of pilot training and net system performance, making simulators of concern to Soviet human engineers. Despite this, Soviet simulator technology generally lags that of the United States.

Soviet human engineers are probably heavily involved in determining the degree of simulator fidelity required to obtain optimal levels of pilot training and—because cost or technological considerations often make the optimum impractical—are probably also involved in prioritizing fidelity requirements in design trade-offs. An example of this approach is apparent in the recent KTS-5 simulator, as configured for the MIG-25P Foxbat. Because the Foxbat is an interceptor rather than an air superiority fighter, Soviet designers reasoned that it did not need a motion system or air-to-air-capable visual system. The visual system is a black-and-white camera model-board system that simulates a 15-kilometer radius around the model-board airfield. The visual system does not have a wide field of view but is merely a single display screen used predominately for takeoffs and landings.

The KTS-6, however, has a full complement of electronic counter-countermeasures equipment, and all types of jamming can be simulated. Ground-controlled intercepts and many emergency conditions can be simulated in all modes. Cost and technology restraints are also shown by the practice of using generic simulators. Rather than producing a distinctive simulator for each aircraft type, the Soviets probably produce only a few types of generic simulators that are then customized to resemble a particular aircraft and programed with appropriate control dynamics. 25X1

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Considering the time and emphasis placed on simulator training in lieu of actual equipment operation by the Soviet Air Forces and, indeed, by the Soviet military generally, the relative lack of sophistication of most Soviet simulators constitutes a significant hindrance to optimally training personnel. Soviet military human engineers are, therefore, probably involved in developing increasingly sophisticated simulators and in proving their value as superior training aids that result in improved operator performance. Soviet human factors researchers are also using flight simulators to test methods of stress reduction and workload evaluation, since simulators are good test beds for human engineering experiments. 25X1

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## Human Performance

Two extreme classes of man-machine systems stress the importance of the human component:

- Poorly human engineered systems, which, although often relatively simple, require operators to have unusual physical or mental abilities for successful operation (for example, wire-guided antitank missiles).
- Highly automated man-machine systems that, even though well designed in a traditional human engineering sense, place the operator in such physically and/or mentally demanding circumstances that he becomes the suspect link in the system (for example, contemporary fighter aircraft).

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The Soviets are strongly emphasizing operator selection based upon psychophysiological research to optimize both types of man-machine systems. Additionally, psychophysiological monitoring systems are being extensively explored for incorporation into critical man-machine systems of the second class. Moreover,

since the effectiveness of any type of man-machine system can be degraded when the human limits of endurance, emotional control, or memory are reached, the potential for human performance enhancement from drugs and biofeedback is being seriously explored. [redacted]

**Operator Selection**

In 1929, the Soviet military operated 31 psychophysiological selection laboratories. With the Stalinist reaction against research regarding individual differences, these were disbanded; and psychophysiological selection research was not renewed until the mid-1950's, when the necessity for identifying personnel who could best operate military equipment became overwhelming. Purely physical (medical and anthropometric) criteria for military personnel were minimally affected by ideological dogma, a fortunate concession given the Soviet need, in some cases, to literally fit men to poorly human engineered equipment. Height requirements for tank crewmen, for example, preclude about 50 percent of Soviet males from consideration. Shorter terms of service and increasingly complex military equipment have amplified the need for improved selection criteria. [redacted]

The earliest and still most widely applied Soviet psychophysiological selection approach involves the determination of the psychomotor abilities of personnel. Despite simple selection factors, preliminary findings from US pilot selection research suggest that psychomotor performance may prove to be a significant indicator of flight school success. Psychomotor testing has probably contributed to the 60-percent reduction in the Soviet military flight school washout rate since the late 1960s and is widely employed for a variety of military occupations. Figure 3 shows a flight school candidate undergoing psychomotor coordination tests. [redacted]

[redacted] the following points are evident: 25X1

- For an increasing number of military occupations, the Soviets are applying psychophysiological monitoring techniques, as well as conventional measures, to the selection process. Selection methods are sometimes juxtaposed: during written tests, a candidate's heart rate, blood pressure, respiration rate, and brain biopotentials may be monitored. This allows the Soviets to collect aptitude, achievement, and stress data simultaneously. 25X1

- In contrast to most Western selection research, nonpathological, generalized characteristics of the electroencephalagram (EEG) (such as alpha frequency amplitude) are still viewed as useful selection criteria.

- Analyses of central nervous system hemispheric dominance, evoked potentials, and magnetoencephalography (recording of the brain's magnetic fields) are considered highly promising for predicting individual performance and for use as future operator selection methods.

- Soviet researchers are attempting to identify individuals with superior adaptability to severe physical and mental stresses and, in fact, presently select personnel for tours in Antarctica and other extreme environments on the basis of certain EEG characteristics. Validation of this technique would obviously have significant impact on the selection and performance of key military operators. 25X1

- Soviet selection research is becoming more mission oriented in its goals. For example, attempts are being made to identify pilot candidates with unusually stable vestibular resistance to optokinetic stimuli for assignments involving frequent low-altitude flights and to create distinct selection criteria for tank commanders, drivers, and gunners. This specificity in operator selection is an important departure from traditional occupational screening and reflects the evolving complexity of Soviet military systems

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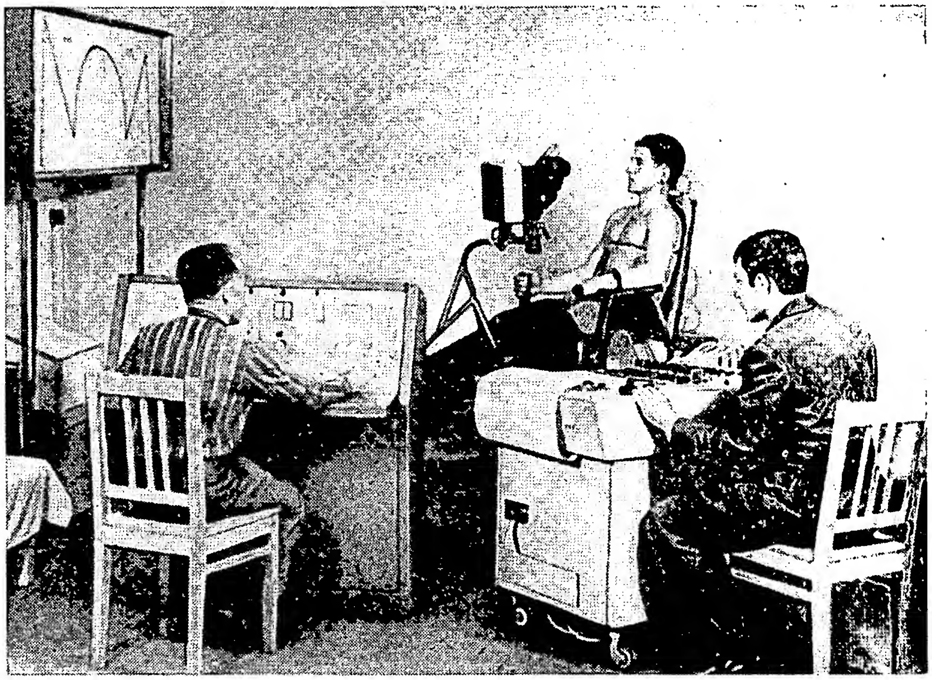

*Figure 3. Flight School Candidate Undergoing Test of Anxiety Effects on Psychomotor Coordination* [redacted] 25X1

and the consequent need for specific aptitudes among crewmen. [redacted]

**Operator Monitoring**

A dominant goal of Soviet human factors researchers, pursued with an emphasis unmatched elsewhere, is the creation of man-machine systems in which the performance-related psychophysiological states of the operators are continuously assessed and characteristics of the man-machine interface automatically altered to reflect the operator's current capabilities. Essentially, this concept amounts to extending the operator selection process into the actual performance of duties. For example, real-time forecasts of probable pilot performance would be made in flight with the computerized assessments driving alterations in pilot control (such as allowable g-loads), modifying displays to reflect the pilot's current visual or cognitive capabilities, or even excluding him from control and transferring to autopilot in the event of incapacitation. Such systems are variously termed "biotechnological," "biocybernetic," or "superadaptive" (the preferred term). [redacted]

The lead development facility for such systems is probably the Special Design Bureau of Biological and Medical Cybernetics in Leningrad. Since at least 1970, the bureau has vigorously pursued the concept and has developed a number of systems that, though significant in their own right, are incremental toward the goal of automatic on-duty monitoring of critical military operators. For example, the bureau has developed a computerized device for rapid preflight evaluation of the psychophysiological condition of aircrewmen and air traffic controllers. The device, designated the Pilot-1 Biotechnical Complex, entered series production in 1981. [redacted] 25X1

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The Pilot-1 can simultaneously examine four persons with an examination time of two minutes per individual. Each examinee inserts a metal plate into the device that contains the coded "norms" of his past responses to the following tests: temperature, pulse rate, electrocardiogram (EKG), arterial pressure, galvanic skin resistance (GSR), reflex time, and joystick tracking coordination. Seated at the Pilot-1, the examinee places his middle fingers into holes in the instrument where the physiological measurements are taken. If any elements of the above test data are outside the individual's normal limits, a physician is alerted. [redacted] 25X1 25X1

The Pilot-1 is envisioned as useful for preduty monitoring of power station operators, railroad engineers, transport drivers, athletes, and military operators. The bureau is currently collaborating with many other Soviet scientific institutions to refine the Pilot series further and broaden the application of psychophysiological monitoring devices. These include the various physiology institutes of the Soviet and Ukrainian academies of sciences, the Neurocybernetics Institute of Rostov State University, and the Ergonomics Laboratory and Chair of Psychology at Leningrad State University. [redacted]

A new psychophysiological testing system, called Pilot-4, is under development. It will be used to screen flight school candidates. Similar systems will monitor the condition of pilots during simulated and actual flights. A Pilot-6 is also planned and will apparently be a psychophysiological monitoring device designed for the needs of human factors specialists engaged in aircraft design. [redacted]

Superadaptive systems and systems that employ psychophysiological monitoring of operator states could have a major impact on numerous military selection, training, and mission-performance capabilities (for example, vigilance, information processing, and decisionmaking). Such systems are becoming well established, and rapid progress regarding the neurophysiological mechanisms of behavior are anticipated. The necessity for defining and allowing for individual differences in physiological responses ("tuning" the monitoring system to reflect an individual's physiological signals and performance) together with the difficulties of monitoring multiple physiological responses (EEG plus EKG, for example)—particularly in physically active operators—argues that such Soviet systems will first be applied to relatively sedate and highly critical operators. Also for active operators, Soviet research regarding psychophysiological correlates of human performance is likely to emphasize the informational value of relatively noninterfering techniques, such as voice stress analysis, evoked potentials, EKG, and GSR used singly. [redacted]

Although no Soviet superadaptive system is known to be operational, we believe that several advanced superadaptive versions of specific military systems are under development. These systems include a superadaptive sonar, a superadaptive air traffic control system, and probably a superadaptive flight cockpit. [redacted] 25X1

We expect the incorporation of psychophysiological monitoring devices in training simulators to precede the fielding of superadaptive systems. This trend appears to be well under way. In laboratory research, Soviet air force flight simulators have been equipped with monitoring devices, and "norms" have been established that relate specific flight situations to allowable psychophysiological reactions on the part of the student. The medical chief of the Air Forces has indicated that they want to provide all simulators with equipment for registering psychophysiological data so that marginally trained individuals working at their limits can be identified. Although the fidelity of simulation is generally lower in Soviet training devices than in comparable US equipment, the incorporation of monitoring devices for objective assessment of stress levels experienced by trainees would provide the Soviets a novel and useful capability not generally considered in US simulator development. [redacted]

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**Performance Enhancement**

[redacted] 25X1 This emphasis springs from significant operator errors observed in military exercises and the Soviet perception that these problems would be greatly magnified in wartime, severely reducing operational effectiveness. Operator and troop performance decrements resulting from fatigue (for example, continuous operations and extended vigilance) and excessive emotional stress (threatened or actual employment of nuclear, chemical, or biological weapons) are of greatest concern to the Soviets. Although a variety of techniques are being examined to minimize operator errors in specific situations (including novel approaches such as hypnosis and electrostatic field effects on the central nervous system), the behavioral modification techniques most likely to affect the effectiveness of Soviet military man-machine systems

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are biofeedback and drug therapy. Biofeedback is probably still at the experimental stage in Soviet military research, but drugs, particularly psychotropic substances, are probably currently available for certain high-intensity combat situations. [redacted]

The Soviet intent to incorporate psychophysiological monitoring devices into critical man-machine systems facilitates the serious consideration of biofeedback as a means of enhancing the performance of key operators, such as pilots, cosmonauts, radar, and sonar personnel. As of the late 1970s, the MOP was funding classified biofeedback research under the concept that operators engaged in stressful activities could learn optimal mental states and maintain high performance. Although the details of biofeedback methodologies employed in classified Soviet research are unknown, one project (possibly imitative of successful US naval research performed with sonar operators) involved the deliberate suppression of theta-wave activity in the EEG resulting in increased alertness. Biofeedback is also viewed as potentially useful for ameliorating cosmonaut space sickness, anxiety, and fatigue. [redacted]

The use of drugs as a means of enhancing selected aspects of human performance, potentially, has wide military application and, for the Soviets, has historical precedence. During World War II, the then recently synthesized amphetamine compounds were approved for Soviet military use and were probably widely employed, particularly by pilots. Drugs with tranquilizing properties—anxiolytics and neuroleptics—were discovered in the 1950s. These drugs also became subjects of Soviet military performance research because they made feasible the modification of excessive material stress. It is probable that military psychotropic drug research programs have since continued steadily. Openly reported performance-oriented experiments have involved virtually all categories of personnel—airborne, artillery, signal, gunners, raw recruits, pilots, cosmonauts, and divers. Large-scale troop tests would be prudent in establishing military performance trade-offs (for example, alertness versus increased anxiety) inherent in the use of psychotropics; such tests involving an amphetamine compound were reportedly done in the late 1960s. We do not know if similar tests involving the general administration of tranquilizers or antidepressants have been conducted, but the presence of the potent tranquilizer/antiemetic perphenazine in Soviet individual chemical-biological-radiation (CBR) antidote kits suggests that they have. [redacted] 25X1

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The current Soviet doctrine on the use of psychotropics in combat is unknown; however, both the Czechoslovak and East German Armies [redacted] intend to issue amphetamines to severely fatigued troops in wartime. [redacted] Soviet plans exist which commend the use of psychostimulants and probably tranquilizers in certain high-intensity combat situations. Our absence of firm knowledge regarding the use of drugs constitutes a significant intelligence gap in estimating current Soviet military effectiveness since psychotropics have the potential for dramatically improving or degrading operator/troop performance, depending on the drugs employed, instructions for their use, and personnel compliance. [redacted]

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Soviet military pharmacological researchers developing improved compounds and classes of drugs for performance enhancement will probably benefit less from their expertise than from their willingness to apply known drugs to novel uses and the virtual absence of protocols for human experimentation in the Soviet Union. The absence of protocols allows them to conduct scientifically valuable research that could not be done in the West. As the biochemical bases of human performance become increasingly well understood, the Soviets will attempt to apply pharmacological research results against additional military performance problems. Key goals currently are believed to include the enhancement of operator memory (particularly short term), increased hypoxia resistance, and rapid correction of circadian disturbances. [redacted] 25X1